THE IMPACT OF INFORMATION AND COMMUNICATION TECHNOLOGY ON ROAD FREIGHT TRANSPORTATION

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Surveying the recent trend toward e-commerce and computerization in the trucking industry, this paper establishes a framework for analyzing the impact of information and communication technology on road freight transportation in terms of commerce, logistics and fleet management, and proposes hypothetical mechanisms of influence. The authors note that the rapid growth of e-commerce and freight fleet management systems make it difficult to arrive at firm, statistics-based conclusions about their impact on road freight transportation, but suggest that more sophisticated government management of transportation demand as well as freight fleet management systems could cancel out the negative impact of e-commerce on road transportation.

Key Words: EC (Electronic Commerce), EDI, Logistics, ITS (Intelligent Transportation Systems), FFMS (Freight Fleet Management Systems)

1. INTRODUCTION

E-commerce is growing as the cost of information and communication equipment, as well as communication fees, fall and the number of Internet users rises. Although e-commerce liberates sellers from the need to maintain a store, and buyers from the need to visit one, it requires the delivery of goods from seller to buyer. This has led some to argue that e-commerce will increase road freight transportation and lead to worse urban road congestion[1].

At the same time, other research suggests that information and communication technology (ICT) will have a positive effect on traffic. For example, once e-commerce has reached a certain level of diffusion there may be reduced use of private vehicles for shopping[2] and more efficient joint delivery systems based on shared operational information that work to prevent an increase in traffic volume[3].

Research focusing on ICT's impact on passenger and freight transportation has existed for some time[4] but the recent rapid growth of e-commerce, computerization of truck transportation providers and trends in e-government make necessary the establishment of a new analytical framework. This paper establishes a framework for analyzing the impact of ICT on road freight transportation in terms of commerce, logistics and fleet management, and proposes hypothetical mechanisms of influence.

2. A FRAMEWORK FOR EVALUATING THE INFLUENCE OF ICT

2.1 Developments in ICT

In recent years, the cost of personal computers and peripherals has dropped sharply even as their processing power and storage capacity have skyrocketed. Likewise, as the growth of broadband and always-on Internet connections illustrates communication fees continue to drop even as connection speeds increase. The lower cost and higher functionality of information and communication systems has had a profound effect in increasing the population of Internet users and fostering the growth of e-commerce.

In the transportation field, Intelligent Transportation Systems (ITS) like car navigation systems and VICS (Vehicle Information and Communication System), which provides drivers with traffic information, have begun to find their way into private vehicles. For commercial vehicles it is now easy to track the location of vehicles and freight using GPS, and apply such information to the optimization of travel routes and freight arrival times. In addition, great promise is also seen for the use of electronic tags (RFID) and Dedicated Short Range Communication (DSRC) systems such as the ETC system used to collect highway tolls.

Internet-accessible mobile phones have rapidly become commonplace and, together with their ability also

to use e-mail messaging services, are used to find road traffic information. Business uses for such phones include everything from management of a salesperson's schedule to logistics applications like photographing the inside of a shipping container with the internal digital camera and sending the image overseas to show how an item was packaged. In fact, by the end of September 2004 the number of mobile phone users had reached 89 million. The total number of GPS-equipped mobile phones sold through 2003 is estimated to have been roughly 12 million.

2.2 Logistics system stakeholders

E-commerce is defined as "doing business over the Internet" and includes business-to-customer (B2C) transactions like those at Internet bookstores as well as business-to-business (B2B) transactions. To enable a closer examination of the role of logistics-related e-commerce we further divide businesses (B) into shippers (manufacturers, wholesalers and retailers) (S) and logistics service providers (such as transportation, fowarding and warehousing companies) (L). Generally when people refer to B2B they mean S2S. ICT has the greatest impact on logistical efficiency at the point between the logistics service provider and the shipper (L2S) where the shipper purchases logistics services. In looking at the impact of ICT on logistics we must specify the relationships between the stakeholders, including government (G) as well as the above-mentioned S, L and C(Fig. 1).

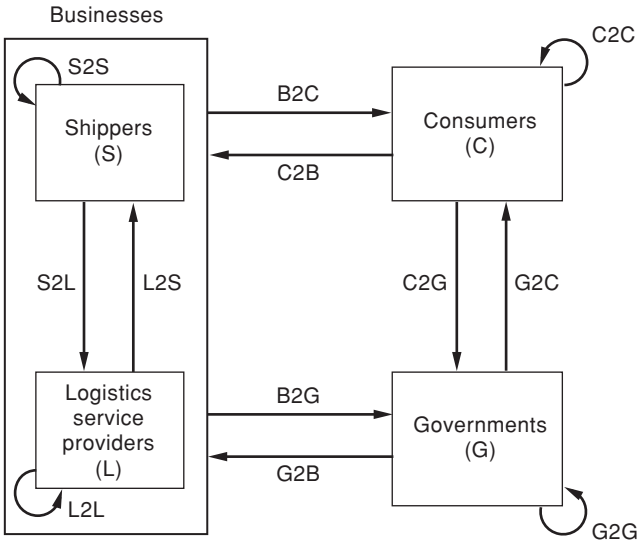


Fig. 1 Logistics system stakeholders

Shippers include both consigners and consignees, who share a concern with minimizing the lead time between receipt of an order and delivery of goods, reducing the opportunity cost that accompanies fluctuations of supply and demand and maximizing the profit associated with the sale of goods. Some shippers make a point to conduct logistics functions in-house in order to gain a competitive advantage. In general, however, there is a growing trend toward outsourcing such functions to logistics service providers as a way to reduce costs.

To meet shipper demands, logistics service providers try to minimize logistics costs (transportation costs and storage costs as well as general management costs including information processing). Meanwhile, growing demand from shippers for services such as time-specific delivery, temperature control and cargo tracking works to increase such costs.

Consumers seek to maximize their consumer surplus by purchasing what they want at low cost. While cost is an important factor in consumer satisfaction, consumers are willing to bear a certain additional cost if they can obtain the items they want in a timely manner. Meanwhile, consumers who live along major roads bear the effects of traffic congestion, traffic accidents and environmental degradation such as air and noise pollution. Needless to say, they would prefer that such problems were alleviated and a more pleasant urban environment maintained.

In general, government is assumed to seek maximization of social welfare (overall benefits minus overall costs). While e-commerce and logistics are private sector activities, government involvement is appropriate in areas such as providing public funds to support transportation and information infrastructure projects, adopting regulations to ensure safety, internalization of external costs, efficient and appropriate resource allocation and the fair income distribution.

2.3 The impact of ICT on logistics systems

Information and communication technologies, particularly the growth of the Internet and ITS, are having a variety of effects on logistics systems[5]. Such effects can be divided into three categories(Fig. 2).

(1) The Internet increases B2B and B2C transactions, leading to greater transportation demand (e-commerce).
(2) The Internet and ITS create more sophisticated markets for L2S and L2L transactions and promote freight consolidation (e-logistics).
(3) ITS promotes optimization of fleet management based on traffic and other real-time information, leading to better transportation efficiency (e-fleet management).

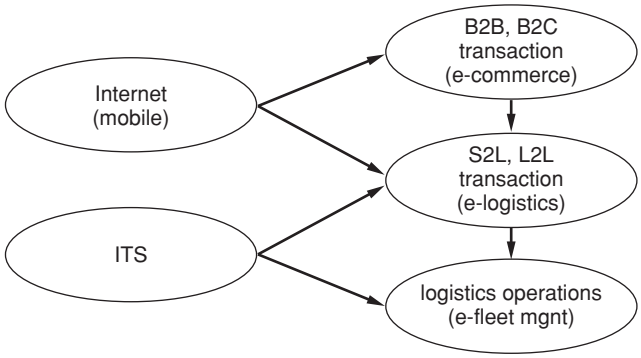


Fig. 2 ICT and logistics system

E-commerce changes the supply chain; it enables manufacturers, wholesalers and retailers to perform transactions directly with consumers. As a result, small and mid-sized companies in outlying areas can sell their products directly to consumers overseas. The change affects not only B2C but also B2B transactions. The Internet offers a means of dealing with small and mid-sized firms while at the same time offering a means to find the lowest-cost provider of mass-produced items.

E-logistics, that is, e-commerce in logistics services markets, is expected to increase competition by adding the potential business partners and enabling wide-ranging searches for cost information. As competition grows fiercer, weaker logistics services providers will be weeded out or reorganized. At the same time, the tendency to reduce costs by outsourcing in-house logistics operations to outside providers can be expected to continue.

As competition heats up, logistics services providers will have to work to reign in costs even as they work to meet shipper demands for services such as time-specific delivery and temperature control. E-fleet management – fleet management that implements ITS – can contribute to greater transportation efficiency. The clearest example is GPS-based vehicle tracking systems. Further efficiency can be expected from the use of vehicle and freight-specific data culled from Dedicated Short Range Communication (DSRC) systems and electronic tags (RFID) in combination with route planning based on road traffic information and digital road maps.

3. THE IMPACT OF ICT ON ROAD FREIGHT TRANSPORTATION

ICT exerts an effect on road freight transportation through the development of e-commerce, e-logistics and e-fleet management. Here, in addition to offering some hypotheses concerning ICT's impact and the role of government, we examine data that addresses whether some of these trends are already underway, measuring road freight transportation in tons, ton-km, vehicle-km and urban vehicle-km. In general, increases in freight transportation volume in tons and ton-km are accompanied by increases in vehicle-km and urban vehicle-km but private-sector efforts such as joint delivery and government introduction of road pricing may work to limit increases in vehicle-km and urban vehicle-km.

3.1 Hypothesis: E-commerce will increase consumer demand

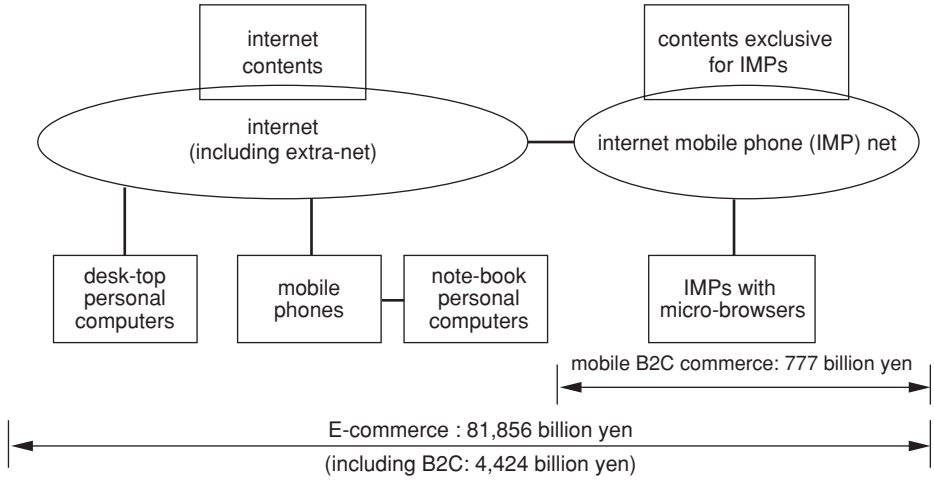
E-commerce creates consumer demand that may lead to higher demand for freight transportation. Consumer demand is believed to rise because of the spread of the Internet means saving in transaction cost that lead to lower prices, careful B2C marketing that leads to better matching of products with consumer needs, and increased value-added that changes in the amount the consumer is willing to pay.

Turning now to some related statistical data, e-commerce is still growing, from nine trillion yen in 1998 to 82 trillion yen in 2003 (Fig. 3). E-commerce can be divided into a seventy-seven trillion yen B2B market and a four trillion yen B2C market, with the mobile B2C market for transactions through mobile phones growing especially fast. Nevertheless, despite the nine-fold growth in e-commerce during the five years since 1998, household consumption expenditure has fallen in each of those years, suggesting that e-commerce has not caused an increase in consumption expenditure.

3.2 Hypothesis: E-commerce will foster increased orders for logistics providers, particularly parcel delivery services

E-commerce will reduce shipping volume. Transportation to retail stores has generally been by pallet or returnable container. E-commerce creates a need to ship a variety of items as individual units. Furthermore, the fickle consumer wants immediate delivery. Unable to cope with theses demands, more and more shippers who have conducted their own logistics operations in-house are outsourcing to logistics services providers, particularly the parcel delivery services.

Increased demand for parcel delivery could increase market concentration in the hands of a few major transportation companies. Most smaller transportation companies rely on chartered transport and lack the network of



Source: http://www.eom.or.jp

Fig. 3 E-commerce in Japan in 2003

sales offices needed to combine numerous smaller clients or the truck terminals with sorting operations necessary to conduct trunk route operations. As with such facilities networked, special services like inspection, cargo tracking and return and repair are only available from the major players.

Statistics demonstrate the increasing role of logistics service providers. The share of vehicle-km freight traffic volume accounted for by commercial trucks has steadily increased, from 17.6% in 1980 to 34.4% in 2001 (Table 1). Commercial vehicles carry mixed loads so they also have a higher loading ratio than private vehicles. The increase in commercial vehicles should lead to an increase in transportation efficiency and reduction in traffic in terms of vehicle-km. In practice, however, traffic volume in terms of vehicle-km was already increasing in the 1980s even before e-commerce due to smaller lot shipping and time-specific delivery, an increase too great to be offset entirely by the rising share of commercial vehicles.

Parcel delivery has increased at a rate of 10% annually from 1.8 billion parcels in 1998 to 2.8 billion in 2003, but it is impossible to know what share of the freight originated in e-commerce. Overall freight traffic demand in Japan in tons or ton-km is falling. Seen by mode, however, there is a slight rise in automotive ton-km, although it is difficult to draw conclusions about any relationship to e-commerce or the growth in parcel delivery services.

3.3 Hypothesis: E-logistics can reduce the volume of freight transportation

Schemes to match cargos and trucks are nothing new. Logistics service providers have long communicated

Table 1 Freight traffic in Japan in terms of vehicle-km, ton-km and tons

	Freight Traffic in Vehicle-km			Freight Traffic in Ton-km (Billions)	Freight Traffic in Tons (Millions)
	Billion Vehicle-km	Commercial Trucks (%)	PrivateTrucks (%)		
1980	136	17.6	82.4	179	5,318
1985	139	22.1	77.9	206	5,048
1990	159	26.6	73.4	274	6,114
1995	166	30.6	69.4	295	6,017
2000	165	34.2	65.8	313	5,774
2001	164	34.4	65.6	313	5,578

Source: http://www.mlit.go.jp/

Note: Freight traffic in vehicle-km excludes special kind vehicles and small trucks.

over the phone to cooperate in finding backhaul freight for empty trucks. Recently such efforts have moved to the Internet and now even involve shippers directly. Load efficiency can be improved and loaded miles increased through joint pick-up and delivery systems involving multiple shippers. Internet-based systems for joint pick-up and delivery are now being adopted by logistics services providers and shippers.

Internet-based systems for matching cargos and trucks underwent something of a boom and increased rapidly a few years ago but the simple information-sharing sites and freight charge auction sites have largely disappeared. Today, only those systems for matching cargos and trucks that operate between qualified logistics services providers remain in active use. Among websites run by shippers' logistics subsidiaries (non-asset based systems) are companies that provide third-party logistics (3PL) services in conjunction with inventory management and distribution processing.

Unfortunately, there are many obstacles to actual operations and few examples of successful joint pick-up and delivery systems are to be found. It is particularly difficult to determine cost and profit in such collaborations and maintain an equitable distribution among partner firms handling differing volumes of freight[6]. In addition, it is difficult for parcel delivery services, for which pick-ups double as sales and marketing calls, to defer work to others.

3.4 Hypothesis: ITS will improve transportation efficiency

Dispatch centers can access road traffic information as they direct deliveries and routings. This increases their accuracy in predicting vehicle arrival times and improves their ability to respond quickly and accurately to customer inquiries. Recently, compilations of GPS data have enabled route selection and coordination of departure times by day and time that improve the accuracy of arrival times. Real-time road traffic information is available not only at dispatch centers but also to drivers through mobile phones. Drivers are now able to contact customers directly.

Automatic Vehicle Identification/Automatic Equipment Identification (AVI/AEI) is also expected to contribute to improved transportation efficiency and security. For example, a trailer could be automatically identified, given permission to enter a container yard and instructed where to drop its load. The ISO is standardizing data dictionary and message sets in anticipation of an international, inter-modal freight tracking system.

That many trucking companies are small and mid-sized has prevented the spread of ICT. Usage has finally increased, however, with the recent availability of inexpensive, high-speed, always-on Internet access in offices and the development of vehicle-side applications incorporating GPS and packet communication. In the four years starting in 2000, there were a total of 37,400 vehicles equipped with GPS-based tracking systems and another 86,000 (including 9,200 units of hybrid type with GPS) equipped with digital tachographs that provide speed and other information to improve driving safety and economy, for a total of 114,200 vehicles[7] (Table 2).

Table 2 Diffusion of in-vehicle equipment

Year	GPS	Digital Tachograph
2000	4,100	12,000
2001	12,600	29,000
2002	21,400	53,000
2003	37,400	86,000

Source: Yano Research Institute (2004)

3.5 Hypothesis: Transportation demand can be managed through government investment in information infrastructure

As the ICT is applied to logistics operations for shippers and logistics service providers, attention is turning to the role of government. In particular, there is a need to develop databases of digital road maps and road traffic information systems as a form of public infrastructure. Development of inexpensive, easy-to-use databases would lead the private sector to develop various e-logistics and e-fleet management services[8].

There is also a need for government to better regulate transportation demand through information and communication technology. Applications might include monitoring of hazardous materials transport or guiding vehicles along low-risk routes using vehicle identification and mobile communication systems. This could contribute to improved safety and response in the event of natural disaster or accident. Road pricing schemes could be adopted that vary the amount charged based on vehicle type and level of congestion. Environmental road pricing that directs large trucks, at a discount, to routes with a lower environmental impact on the surrounding area is being implemented on roads such as Tokyo's Metropolitan Expressway.

The hypotheses described above can be summarized as shown in Figure 4, which depicts how freight volume measured in tons, ton-km, vehicle-km and urban vehicle-

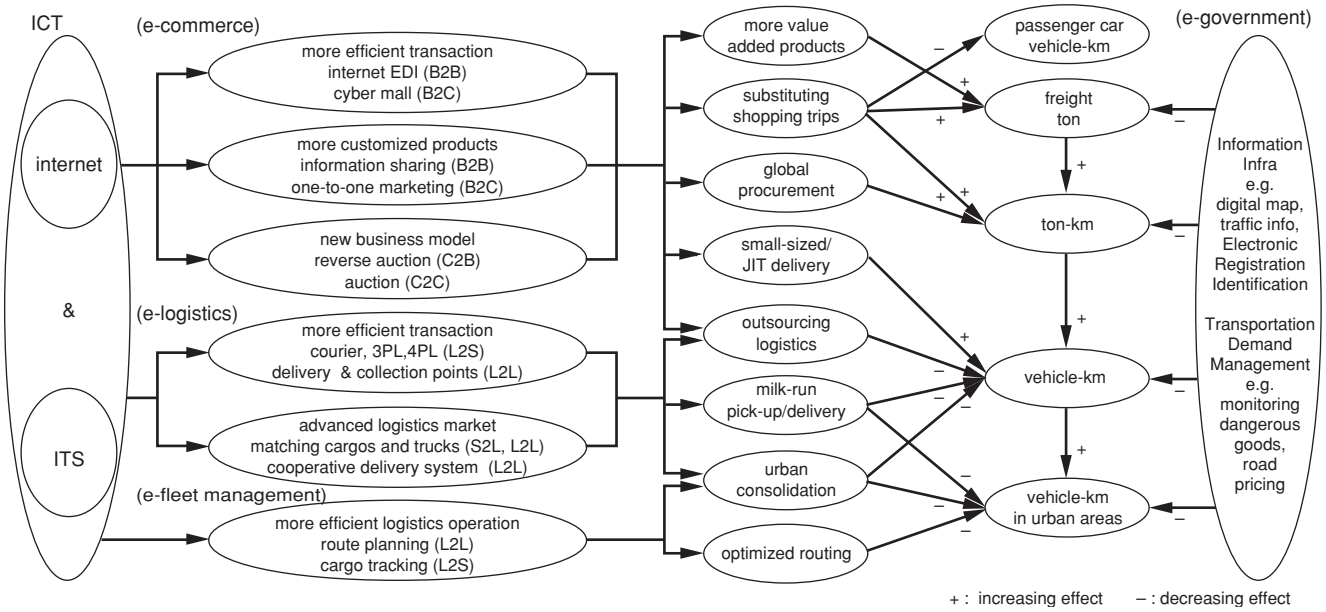


Fig. 4 Impacts of ICT on logistics system

km is influenced by other factors. Arrows marked with a "+" indicate a direct increasing relationship between one variable and the other, while those marked with a "-" indicate an inverse relationship.

4. CONCLUSIONS

Information and communication technologies are having an enormous influence on road freight transportation. This paper has established a framework for evaluating their impact not only in terms of e-commerce but also in terms of the computerization of the logistics market and the increasing sophistication of fleet management systems.

The broad impact of ICT on road freight transportation combines a trend toward increase caused by the growth in e-commerce with a trend toward decrease caused by improved transportation efficiency. A dearth of concrete examples and statistical data, however, makes it difficult to reach clear conclusions about the overall impact of ICT at the current time. In particular, it is impossible to determine the degree to which e-commerce has increased the volume of parcel delivery and road freight transportation. There is a need for further monitoring of trends in the development of information and communication technology as well as the latest efforts by shippers and logistics providers, and for continued observation and evaluation of the changes in road freight transportation that result.

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